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TRANSLATOR'S DECLARATION

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solemnly declare:

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that I have, to the best of my ability, prepared the attached accurate, complete and literal translation of the German language text of:

PCT International Application PCT/DE2005/001206, as filed on July 7, 2005.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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Arrangement for Detecting a Shaft Break in a Gas Turbine and a Gas Turbine

The invention relates to an arrangement for detecting a shaft break in a gas turbine. Furthermore, the invention relates to a gas turbine.

Gas turbines constructed as aircraft engines comprise at least one compressor, at least one combustion chamber and at least one turbine. Aircraft engines are known in the prior art which on the one hand comprise three compressors positioned upstream of the combustion chamber and three turbines positioned downstream of the combustion chamber. The three compressors comprise a low pressure compressor, a medium pressure compressor and a high pressure compressor. The three turbines comprise a high pressure turbine, a medium pressure turbine and a low pressure turbine. According to the prior art, the rotors of the high pressure compressor and of the high pressure turbine are connected with each other by a shaft. The medium pressure compressor rotor and the medium pressure turbine rotor are interconnected by a shaft. The low pressure compressor rotor and the low pressure turbine rotor are interconnected by a respective shaft. The three shafts concentrically enclose one another and are therefore nested within one another.

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For example, if the shaft that interconnects the medium pressure compressor with the medium pressure turbine breaks, then the medium pressure compressor can no longer take-off work or power from the medium pressure turbine. As a result, an excessive rotational speed (racing) can occur at the medium pressure turbine. Such racing of the medium pressure turbine must be avoided because thereby the entire aircraft engine can be damaged. Thus, for safety reasons a shaft break in a gas turbine must be detectable with certainty in order to stop a fuel supply to the combustion chamber when a shaft break occurs. Such a detection of a shaft break makes difficulties particularly when the gas turbine as described above comprises three shafts arranged concentrically one within the other and thus nested one within the other. In this case particularly the detection of a shaft break of the intermediate shaft which couples the medium pressure turbine with the medium pressure compressor, makes difficulties.

Starting with the foregoing it is the underlying problem of the present invention to provide a new arrangement for the detection of a shaft break in a gas turbine.

This problem has been solved by an arrangement for detecting a shaft break in a gas turbine according to patent claim 1. According to the invention, an arrangement is suggested for detecting a shaft break at a rotor of a first turbine particularly a medium pressure turbine of a gas turbine, particularly of an aircraft engine whereby a second turbine,

particularly a low pressure turbine, is positioned downstream of the first turbine, with an operator element positioned between the rotor of the first turbine and a stator of the second turbine radially inwardly relative to a flow channel, and with a sensor element guided in the stator of the second turbine in order to convert a shaft break detected by the radially inwardly positioned operator element, into an electrical signal and to transmit this electrical signal to a switching element which is positioned radially outwardly relative to the flow channel on a housing of the gas turbine.

According to the present invention, thus an arrangement for detecting a shaft break is suggested with a mechanical operator element which is positioned radially inwardly relative to a flow channel of the gas turbine between a rotor and a stator of two neighboring turbines. A shaft break of the upstream positioned turbine is detectable with the aid of the operator element whereby the operator element is axially displaced in response to a shaft break to thereby hit the sensor element. The sensor element is preferably constructed as an impact sensor the structure of which is changed in response to an impact of the operator element on the sensor element which produces an electrical signal representing the shaft break. The sensor element is guided in the stator of the downstream positioned turbine and conducts the electrical signal representing the shaft break radially outwardly to a switching element. The sensor element can be pulled out of the assembled gas turbine in the radial direction of the same. Thereby it is assured that with

an assembled gas turbine, all electrical components of the arrangement according to the invention for detecting a shaft break are easily accessible without the need for dismantling the gas turbine. The sensor element can be easily pulled out in the radial direction of the assembled gas turbine and the switching element is positioned radially outwardly on the housing of the gas turbine.

Thus, all electrical structural components of the arrangement according to the invention for detecting a shaft break can be inspected or maintained without any large maintenance effort and expense. All structural components of the arrangement according to the invention for detecting a shaft break which are accessible only by dismantling the gas turbine, for example the operating element, are of purely mechanical construction and are very reliable. Therefore, these structural components require maintenance less frequently than the electrical or electronic structural components.

The gas turbine according to the invention is defined in the independent patent claim 9.

Preferred embodiments of the invention are defined by the dependent claims and the following description. An example embodiment of the invention is described in more detail with reference to the drawing without being limited thereto. Thereby

Fig. 1 shows a portion of a gas turbine according to the invention with an arrangement according to the invention for detecting a shaft break in a gas turbine.

In the following, the present invention is described in greater detail with reference to Fig. 1.

Fig. 1 shows a partial cross-section through a gas turbine according to the invention, namely an aircraft engine. The cross-section shows a radially inwardly positioned area between a rotor of a medium pressure turbine 10 and a stator of a low pressure turbine 11. A rotor disk 12 of the intermediate pressure turbine 10 is illustrated. The rotor disk 12 is part of the last rotor blade ring of the intermediate pressure turbine 10 as seen in the flow direction (arrow 15). A radially inwardly positioned sealing structure 13 of the stator of the low pressure turbine 11 is shown of the first guide vane ring of the low pressure turbine 11 as seen in the flow direction. The sealing structure 13 comprises honeycomb seals 14 of a so-called "inner air seal" sealing.

The flow direction through the gas turbine is shown in Fig. 1 by an arrow 15. Thus, the stator of the low pressure turbine 11 is positioned downstream of the rotor of the medium pressure turbine 10. Thereby, as seen in the flow direction, the first or frontmost guide vane ring of the low pressure turbine 11 borders on the last or hindmost rotor blade ring of the medium turbine

10 as seen in the flow direction. Upstream of the medium pressure turbine 10 there is preferably positioned a high pressure turbine.

As mentioned, in such gas turbines which comprise three turbines and three compressors, the rotors of the high pressure turbine and of the high pressure compressor are interconnected, the rotors of the medium pressure turbine and of the medium pressure compressor are interconnected, and the rotors of the low pressure turbine and of the low pressure compressor are interconnected respectively by a shaft. Thereby, the three shafts are arranged concentrically to enclose one another and thus are nested one within the other. According to the present invention, to provide an arrangement for the detecting of a shaft break in a gas turbine which arrangement is particularly suitable for detecting a shaft break of the shaft which interconnects the rotor of the medium pressure turbine with the rotor of the medium pressure compressor. When this shaft breaks, the medium pressure compressor can no longer take off work or power from the medium pressure turbine which leads to racing of the medium pressure turbine. Such racing of the turbine can lead to severe damages to the aircraft engine. Therefore, such a shaft break must be detected with certainty.

In accordance with the present invention it is suggested to position an operator element 16 between the rotor of the medium pressure turbine and the stator of the low pressure turbine 11. In the illustrated embodiment the operator element 16 is

positioned between the last rotor blade ring of the medium pressure turbine 10, as seen in the flow direction, and the first guide vane ring of the low pressure turbine 11 also as seen in the flow direction. Thereby, the operator element 16 is positioned radially inwardly relative to a flow channel within the gas turbine and neighboring to the rotor disk 12 of the last rotor blade ring of the medium pressure turbine 10 as seen in the flow direction.

According to Fig. 1 the operator element 16 is axially oriented and guided in the sealing structure 13 serving as a sealing carrier. For this purpose a bore with an inner threading is provided in the sealing structure 13 whereby a nut 17 with a respective outer threading is secured in the bore of the sealing structure 13. The nut 17 in turn has a central bore in which the operator element 16 is guided and displaceable in the axial direction.

As shown in Fig. 1, the operator element 16 which is mounted or guided in the nut 17 for displacement in the axial direction, is fixed in an axial position by a shearable pin 18. The shearable pin 18 extends substantially in the radial direction and reaches radially from the outside through the nut 17 into a respective hole within the operator element 16. By means of the shearable pin 18 and the thereby caused axial fixing of the operator element 16 it is assured that during normal operation or regular operation of the gas turbine no axial displacement of the operator element 16 occurs.

As further shown by Fig. 1, a washer 19 is arranged between the sealing structure 13 and the nut 17. By means of the thickness of this washer 19 a spacing may be adjusted between the rotor disk 12 and an end 20 of the operator element 16 neighboring the rotor disk 12.

In addition to the operator element 16 the present invention comprises a sensor element 21 for detecting a shaft break. The sensor element 21 is constructed as an impact sensor which cooperates with the end 22 of the operator element 16 opposite the end 20 in such a way that when the second end 22 of the operator element 16 impacts on the sensor element 21 in response to a shaft break, the sensor element 21 produces an electrical signal representing the shaft break in order to transmit this electrical signal to a switching element positioned radially outwardly on a housing of the gas turbine. The sensor element 21 is guided in the low pressure turbine 11 and can be retrieved in the radial direction out of the stator of the low pressure turbine 11.

As shown in Fig. 1 the radially inwardly positioned end of the sensor element 21 is guided in a mounting 23. The mounting 23 is secured to the sealing structure 13 by a bracket 24. As shown in Fig. 1 the bracket 23 is rigidly secured to the sealing structure 13 by a rivet connection 25. The mounting 23 held by the bracket 24 has an opening in the area of the end 22 of the operator element 16 in order for the operator element 16 to be

moved in the direction onto the sensor element 21 in case of a shaft break.

Fig. 1 shows the arrangement according to the invention for detecting a shaft break or rather the respective gas turbine in an arrangement corresponding to the regular or normal operation of a gas turbine. The operator element 16 is fixed by the shearable pin 18 against its axial displaceability. If a shaft break occurs on the shaft, which connects the medium pressure turbine 11 with a medium pressure compressor (not shown), then the medium pressure compressor can no longer take off work or power from the medium pressure turbine 10 and a racing of the medium pressure turbine 10 may occur. Due to the pressure conditions in the medium pressure turbine 10, in the event of such a shaft break, the rotor is moved toward the back or in the direction of the arrow 15. In that regard, the rotor is namely the rotor disk 12, shown in Fig. 1, of the last or hindmost rotor blade ring of the medium pressure turbine 10. As a result, the rotor disk 12 impacts on the end 20 of the operator element 16, whereby the pin 18 which serves for axially fixing the operator element 16, is sheared off and the operator element 16 is moved in the direction of the arrow 15 onto the sensor element 21 so that the end of the operator element 16 impacts on the sensor element 21. Hereby, the structure of the sensor element 21 is changed in such a way that an electrical signal representing a shaft break is produced by the sensor element 21. The signal can then be transmitted radially outwardly in the direction toward

a switching element which finally cuts off the fuel supply to the combustion chamber in response to a shaft break.

The sensor element 21 constructed as an impact sensor preferably comprises a ceramic base body into which an electrical circuit is integrated. The structure or integrity of the base body is monitored by the switching element. When the operator element 16 impacts on the ceramic base body of the sensor element 21 in response to a shaft break, the base body is destroyed and the circuit integrated into the ceramic base body is interrupted. The change of the signal provided by the sensor element 21 occurring thereby, represents a shaft break and can be evaluated or further processed in a simple manner by the switching element in order to finally cut off the fuel supply to the combustion chamber.

As mentioned, the sensor element 21 is guided in the stator of the low pressure turbine 11 in such a manner that the sensor element 21 can be pulled in the radial direction out of the stator. Such pulling out of the sensor element 21 in the radial direction out of the stator, particularly of a guide vane of the guide vane ring of the low pressure turbine 11, can be performed with the gas engine mounted or assembled. Thereby it is possible to inspect or perform maintenance work of the sensor element 21 without any large effort. All electrical or electronic structural components of the arrangement according to the invention for detecting a shaft break are thus accessible without any large assembly effort. The remaining structural groups which

are accessible only if the gas turbine is disassembled, of the arrangement according to the invention to detect a shaft break, for example the operator element 16, are of pure, mechanical construction and are very robust and thus can be inspected less frequently or maintenance work needs to be done less frequently than for the electrical or electronic structural components of the same.